



The Corrector

Iteration 7 Substep 2

January 2001

A NEWSLETTER FOR THE NPARC USERS ASSOCIATION

From the Support Team

Version 4.0 of the NPARC Alliance flow solver (WIND), is scheduled to be released in February. Version 4.0 can be downloaded via IVMS by registered users using their IVMS userid and password. If you have forgotten your IVMS password, please contact the NPARC support team to establish a new password.

To become a registered user and receive the NPARC flow simulation software system, a Memorandum of Agreement (included at the end of the newsletter) must be completed and approved by the US Air Force at AEDC.

The annual NPARC planning workshop will be held at AEDC the week of March 19. Following the planning workshop, the AEDC Distributed Center will be hosting a WIND training session for DoD or DoD sponsored users. If you would be interested in attending the training session on the use of WIND and its utility codes, please contact the support team at the email address below for more details.

For support questions, the NPARC support team can be contacted via:

e-mail:
nparc-support@info.arnold.af.mil

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What To Look For In WIND Version 4.0

WIND developers have been busy ever since version 3.0 was released back in February 2000. The result is a much improved code. Following is a list of major enhancements, additional minor capabilities, and noteworthy bug fixes:

New major capabilities

1. The ability to use CGNS files (as opposed to the default Common

File format) has been added (CGNSBASE keyword).

2. Communication between zones in a multi-processor run can now be accomplished using either direct worker-to-worker communication or routing through the master processor. Direct is faster, but sometimes that ties up too many file descriptors, so you need the ability to revert to the old way (ROUTE DIRECT keyword).
3. Extended the rotating coordinate system capability. Rotation rates can be defined independently for each zone (ROTATE keyword). A circumferential averaging zone interface is provided to couple adjacent zones with different rotation rates. A test option was added that allows subsonic inflow to be aligned normal to the inflow boundary or aligned in the positive first computational coordinate direction.

4. Added the capability to compute on overlapping grids with a double fringe (keyword: FRINGE MODE FROZEN). A more complete description on how to use this is in the FAQ's below.
5. Introduced zonal specification for limiting the number of reacting species used with finite-rate chemistry (OMIT THIRD BODY keyword). This can be used to change the reactions occurring in a given zone, even to the point of making the zone chemically frozen.
6. Spalart's Detached Eddy Simulation (DES) technique for turbulence modeling in unsteady flow simulations has now been implemented for the Spalart-Allmaras turbulence model (DES keyword).
7. Added a non-reflecting outflow boundary condition (OUTFLOW NON-REFLECTING), as well as two more compressor face models (COMPRESSOR FACE SAJBEN and COMPRESSOR FACE PAYNTER).
8. The Christoph law-of-the-wall wall function implementation has been modified to be applicable to ideal gas, equilibrium chemistry, and finite-rate chemistry (WALL-FUNCTIONS keyword).

New minor capabilities

1. It is now possible to specify no Navier-Stokes iterations in a zone but still iterate on the turbulence model equations (NAVIER-STOKES ITERATIONS keyword).
2. The complete Spalart turbulence model (including production and destruction terms) has now been implemented (TURBULENCE SPALART keyword).

3. Added TEST option 125 to redirect time history output to the .lis file. This allows time history information to be generated when performing parallel processing even though the .cth file format does not presently support parallel capabilities.
4. The ability to specify a reference Mach number for transition was added (MODELDATA REFERENCE-MACH).
5. Added the ability to control the print frequency of residual and miscellaneous info printed to the .lis file (CYCLES and ITERATIONS PER CYCLE keywords). This does not change the print frequency of integrated data, which is specified as part of the load block.
6. Updated the copyright information printing routine to list all the libraries, and their version numbers, that the code was linked against.
7. You can now restart a solution with a modified zonal grid which has a different size from the original one in the flow solution file. The solution in the modified zone is automatically set to reference conditions unless the user specifies otherwise.
8. Menter SST and Spalart turbulence models now allow for reverse bleed boundaries.
9. A TEST option (46) was added to calculate the turbulent viscosity at a blowing boundary like NASTD did.
10. The make system has been improved to reduce the amount of user intervention required when compiling WIND. Improvements were also made to ease code debugging. The ability to compile

with and without MPI support for various systems was added.

11. The PVM distribution that is included with WIND was upgraded to version 3.4.3
12. You can now run two parallel WIND jobs of the same name on the same machine at the same time.
13. Operator splitting for the reacting chemistry source terms has been implemented to increase the stability of the integration (TEST option 92).

Bug fixes

1. Modified the time step calculation to not check for the zeta time step limit if running 2D. This also required eliminating the cross-flow CFL factor for 2D cases, since, with singular axes, this caused stability problems. Also made the calculation of the cross-flow CFL factor more consistent.
2. Liu-Vinokur equilibrium chemistry should now work (CHEMISTRY keyword).
3. Cleaned up the initialization routines, and added the ability to check and adjust the solution when zonal models change. Specifically, as the turbulence model is changed from one to another, variables are added and deleted as necessary, and intelligent use of the old model's data is made to initialize the new model.
4. Corrections were made to the chemical reaction rate routines to include proper Jacobian computation reflecting the algebraic constraint on the final species.
5. The freestream/arbitrary inflow boundary conditions were

corrected to make use of appropriate speed of sound computations to improve the consistency with the interior scheme.

6. Other serious bugs were fixed which had been dramatically limiting the ability to compute reacting flow simulations.
7. Modifications were made to allow an actuator disk to operate on a zone boundary that couples to the same zone (but the user must specify one iteration per cycle).
8. Fixed the parsing of the IMPLICIT MACCORMACK keyword to allow specification of the number of subiterations.
9. Modified the code to check for the existence of the .dat file, and have it abort gracefully if it does not exist. This allows the user to run the 'windver' executable to get version information without the program dumping core.
10. Do not set MAX_NODES based on number of zones on a restart. This lets WIND run with solution files that were not created with the same algorithm for MAX_NODES. For a restart, set MAX_NODES to MXZONE.
11. ITERATIONS PER CYCLE -1 now works
12. DQ has been made a double precision variable, which may help stabilize the code under some circumstances.
13. Boundaries on the interior of grids are now treated in the same manner as boundaries on grid edges.

Changes with WIND tools

1. Source for all the WIND tools is now available.

2. Binaries for the WIND tools are now also available for Sun, Linux, and Windows systems.
3. Domain decomposition / recombination tools are now available.

The result of all of this is that WIND has taken some large steps toward being the code that the NPARC Alliance envisioned back when we started this effort three and a half years ago. More work is needed (it always is), but the addition of double-fringe capabilities, the improved handling of interior boundaries, and the now-functional chemistry capabilities, give WIND a versatility that is hard to match anywhere.

WIND Demonstration Cases

As part of the HPCMO CHSSI CTA CFD, several demonstrations were accomplished using the WIND code. Below is a short summary of the results. A more complete discussion is planned in future AIAA papers.

Rotating Coordinate System Case-

The rotating frame of reference capability of WIND was extended and demonstrated for three applications. An axisymmetric transonic duct example was used to perform a critical evaluation of WIND for rotating frame of reference calculations.

Calculations of the duct were performed with non-rotating, rotating, and mixed rotating and non-rotating frames of reference. The wall Mach number and flow field Mach contours were nearly identical for the three solutions. A single component

axial flow transonic rotor calculation was performed and calculated total pressure ratio was compared to experimental data.

The rotor calculation was performed using a rotating frame of reference coordinate system and again using a mixture of rotating and non-rotating frames of reference. Excellent agreement with experimental total pressure ratio data was obtained for both solutions. A single stage compressor consisting of guide vane, rotor, and stator was calculated. The calculation demonstrated the ability to perform a multi-component turbomachinery type application. The successful demonstration of WIND for a turbomachinery type application has been performed.

Modifications were made to WIND that allow analysis of coupled rotating and non-rotating frames of reference, such as encountered in analysis of high performance military propulsion systems. (See AIAA-2001-0223)

Multi-Nozzle Rocket Plume Flow Field - The WIND computer program was used in parallel mode (16 processors) to solve the full Navier-Stokes (viscous) equations for chemically reacting flow for a ground based experimental rocket with six nozzles. Symmetry conditions were used to reduce the problem to a sixty degree segment containing two half nozzles. The resulting grid contained 23 zones and 869,036 nodes.

A hydrazine liquid rocket was simulated using an 11 chemical specie, 15 reaction kinetic model of a carbon, hydrogen, nitrogen, and oxygen gas mixture. Predictions of temperature, chemical species concentrations, Mach number, velocity, and density were obtained for the after body, base, nozzle, and multiple plume regions of an experimental liquid rocket. The

ability to model complex three-dimensional rockets with multiple nozzles and multiple plume interactions has been demonstrated.

These results provide input for radiation computer codes to predict plume signatures. The capability of the WIND code to simulate complex chemically reacting flows has been established.

Enhanced Overlapped Grid Capabilities

Several enhancements to the overlapped grid capability have recently been made to the WIND code. The first enhancement deals with the implementation of large cell areas for internal zone boundaries. Within the WIND code, a cell vertex approach is taken in which cell areas are formed around each grid point of the discretized computational domain. During the solution calculation process in WIND, accurate calculation of cell areas is crucial to accurately predicting the flowfield.

For example, incorrect cell areas would lead to inaccurate mass flow calculations along zone inflow or outflow boundaries. Presently, along an external zone boundary, the half cells at the edge of the domain are combined with interior cells to produce a large cell. Use of this large cell for cell area calculations improves the accuracy.

Until now, half cells were used along internal zone boundaries. Under the current effort, to improve the accuracy of internal zone boundary cell area calculations, the large cell method used along external boundaries has been implemented for internal boundaries.

The second enhancement improves the overlapping boundary coupling. WIND supports a multi-zone data structure that can greatly simplify modeling complex geometries. WIND's multi-zone support is quite general and provides the user great flexibility in that it can accept both face-matched and overlapped zone topologies.

However, along with this generality and flexibility comes a development challenge to transfer solution data between zones such that there is a continuous solution across the zone boundaries. For overlapped zones, a key element for solution continuity at the boundaries is the method used to calculate the solution on the fringe points, i.e. the points in the zone where data transfer occurs.

Single fringes, which have been exclusively utilized in WIND until now, can only support first order accurate solution calculation at the fringe points. Under the current effort, double fringes have been implemented to increase solution accuracy for overlapping boundary coupling.

IVMS Enhancements

The WIND system is currently being developed by members of the NPARC Alliance including the USAF AEDC, NASA Glenn Research Center, United Technologies Research Center and Boeing. Developers and users of the WIND system are located in many different geographical locations in the United States. In order to maintain software version control and distribute up-to-date code to developers and users, the Internet Version Management System, IVMS, was developed. Under the current

effort, the IVMS was enhanced in the following ways:

- Reorganized the initialization files and directory hierarchy to allow for multiple sites to be driven from the same IVMS source distribution. This allows completely distinct IVMS projects to be controlled by the same source, thus reducing the required maintenance of the IVMS.
- Documented IVMS installation instructions and provided AEDC and NASA-Glenn updated versions of the IVMS, along with the new system installation instructions.
- Uploaded the source code for the suite of WIND support tools to the IVMS to provide software version control and the ability to distribute source code to developers and users.
- Implemented a default IVMS project and added additional messages for non-developers to guide them through the IVMS download process.
- Implemented the capability for IVMS users with administrator privileges to create new IVMS projects.
- Created an automatic electronic mail notification of IVMS updates to developers.

WIND Support Tools

In order to assist WIND users in the application of WIND, a suite of support tools has been developed. These tools are either batch or interactive utility tools. This suite includes the following tools;

CFAVERAGE – Averages multiple .cfl files

CFBETA – Add zones to a .cgd or .cfl file that are symmetric to existing zones.

CFCNVT - Converts between common files and various other file types.

CFCOMBINE – Combines multiple zones in a .cgd or .cfl file into a single zone.

CFPOST – Post-processor used to examine the contents of the .cfl file.

CFREORDER – Re-orders and/or deletes zones in a .cgd or .cfl file

CFRESET_ITER – Resets the iteration count in a .cfl file to zero.

CFSEQUENCE – Extracts a sequenced .cgd or .cfl from existing unsequenced file

CFSPLIT – Splits a zone (or zones) in a .cgd or .cfl file into multiple.

CFSUBSET – Removes specified grid points from a .cgd or .cfl file.

CFUNSEQUENCE – Takes a sequenced .cgd and .cfl files and move it back to the original .cgd and .cfl

CFVIEW – Used for viewing (as text) the structure and contents of a .cgd and .cfl file.

FPRO – Used for operating on data in a .cfl file.

GMAN – Pre-processor used to specify boundary condition types and zone connectivity in multi-zone grids.

GPRO - Used for operating on data in a .cgd file.

JORMAK – Finds boundary points in a .cgd file and creates a journal file containing information for CFPOST or PLOT3D.

RESPLT – Creates a GENPLOT file containing convergence data from a list output (.lis) file.

TIMPLT - Creates a GENPLOT file containing time history data from a list output (.lis) file.

TMPTRN – Creates a point-by-point wall temperature distribution and/or boundary layer transition data and writes it into the .cfl file for use with WIND's TTSPEC keyword.

WIND users come from many separate organizations across the United States representing industry, government, and academia. As one might expect, there is no one single type of computing platform that is common to all WIND users. The NPARC Alliance has attempted to address this issue in two ways.

First, executable versions of WIND and its support tools are available for several different computing platforms.

The second approach makes source code and makefiles available to users to build executables on computer platforms for which executables are not provided by the NPARC Alliance.

A computer platform that is becoming more popular these days because of its high performance per cost values is the Windows-based PC. Previously, a Windows PC version WIND was made available to users. Under the current effort, the suite of WIND support tools listed above was ported to the Windows PC environment and executables were created and made available to WIND users.

User Association Meetings

There was no user association meeting held in the summer of 2000. The following papers are to be presented at the January 2001 AIAA Aerospace Sciences Meeting:

AIAA-2001-0222

Improving Zonal Coupling Accuracy and Robustness in the WIND Code

T. Michal and M. Oser, The Boeing Company, St. Louis, MO

AIAA-2001-0223

Development and Validation of WIND for Rotating Coordinate Systems

J. Sirbaugh, Sverdrup Technologies, Inc., Arnold AFB, TN

AIAA-2001-0224

Validation and Verification of the WIND Code for Supersonic Diffuser Flow

J. Dudek, D. Davis, and J. Slater, NASA Glenn, Cleveland, OH

AIAA-2001-0225

Assessment of Shock Induced Flow Separation and Shear Layer Mixing Predictions in Nozzles and High Speed Jets

A. Hamed and A. Mohamed, Univ. of Cincinnati, Cincinnati, OH

AIAA-2001-0226

WIND Code Application to External Forebody Flowfields in Comparisons with Experimental Results

F. Frate, Dynacs Engineering, Cleveland, OH; H. Kim, NASA Glenn, Cleveland, OH

AIAA-2001-0227

Use of CFD Methods for Calculating Hypersonic Flows Past Blunt Conical Bodies

M. Khalid, H. Xu, and S. Chen, National Research Council, Ottawa, Ontario, Canada

AIAA-2001-0228

Numerical Predictions of the Transitional Flow Past Blunt Bodies

K.-L. Go and G. Liaw, Alabama A&M Univ., Normal, AL

The following is a list of upcoming NPARC User's Association meetings:

January 2001
AIAA Aerospace Sciences Meeting
Reno, NV
NPARC Alliance Technical Session
NPARC Alliance User's Meeting

January 2002
AIAA Aerospace Sciences Meeting
Reno, NV
NPARC Alliance Technical Session
NPARC Alliance User's Meeting

Please plan to attend one of the User's meetings to let your views be known. You are also encouraged to contribute to the NPARC Alliance technical sessions to communicate your experiences to other users.

Frequently Asked Questions?

The following are some of the more frequently asked questions of the user support team.

How do I use the WIND double fringe capability?

Before using the new Wind double fringe capability, a grid with a double fringe boundary must be generated. This can be done in the GMAN grid generator using the GENERATE FRINGE capability. Under the GENERATE FRINGE menu there is a SET FRINGE-MODE selection. Here you can select a DOUBLE FRINGE mode. This mode must be selected before generating the fringe. In addition to having a double fringe grid, a new keyword must be added to the Wind input file to control the solution mode at fringe points. The new keyword syntax is:

**FRINGE [MODE] [FROZEN]
[[ZONE] zone]**

This keyword causes the solution to remain frozen at fringe nodes during the solution cycle. This mode can be used with single or double fringe boundaries. It is optional with single fringe boundaries, however, it must be used at double fringe boundaries. Running Wind on double fringe grids without this keyword may lead to erroneous results.

Is WIND written in relative coordinate system or can it be used in applications like turbomachinery flow in which everything relative to a rotating coordinate system?

The code may be run in fixed or rotating coordinates. Use the ROTATE keyword to specify how to move the coordinate system. An AIAA paper, AIAA-2001-0223 describes this capability.

I am running a multi-zone problem. Is it possible to run only one zone to convergence before turning the other zones on?

You must run all zones initially for at least one iteration to get the entire flowfield initialized. You can then turn off the blocks you want,

converge your one zone and then turn the other zones back on.

Memorandum of Agreement
AEDC Software Release
U.S. Government

Date:

1. On behalf of the U.S. Government agency listed below, I request release of the following US Air Force software package (computer programs, system description, and documentation):

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Distribution format and media:

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The requested software package will be used as follows:

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2. I understand that the requested software package contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, *et seq*) or Executive Order 12470, and that violations of these export laws are subject to severe criminal penalties. Further dissemination of this software is controlled under DoDD 5230.25 and AFI 61-204, and is limited to object or executable code.

Requester

Signature:

Printed Name:

Requesting Organization:

Address:

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Name, Initials, and Date:

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Test Operations Directorate

Arnold AFB. TN 37389-9010

Requester: Technical Contact

Name:

Phone Number:

E-Mail Address:

Memorandum of Agreement
AEDC Software Release

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The requested software package will be used as follows:

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- a) The Requester shall not knowingly release or disclose the Package to third parties (other than the Requesting Organization).
 - b) To strictly abide by and adhere to any and all restrictive markings placed on the Package.
 - c) That any restrictive markings on the Package shall be included on all copies, modifications, and derivative works, or any parts or options thereof, in any form, manner or substance, which are produced by the Requester including but not limited to incorporation of the Package into any other data, technical data, computer software, computer software documentation, computer programs, source code, or firmware, or other information of like kind, type or quality. In all such events, Requester shall clearly denote where such Package derived data initiates and concludes by use of annotations or other standard markings.
3. The Requester and the Software Release Authority agree that:
- a) No guaranties, representations, or warranties either express or implied shall be construed to exist in any language, provision, or term contained in these materials or in any other documentation provided herewith (all such items are collectively referred to as the "Agreement"), and furthermore, the releasing organization disclaims and the Requester waives and excludes any and all warranties of merchantability and any and all warranties of fitness for any particular purpose.
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4. The Requester's use of the Package shall not prevent the Government from releasing the Package at any point in the future.
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6. The Requester may use the released Package in a contract with the Government, but understands that the Government shall not pay the Requester for rights of use of such Package in performance of Government contracts or for the later delivery to the Government of such Package. The Requester may be entitled to compensation for converting, modifying, or enhancing the Package into another form for reproduction and delivery to the Government, if authorized under a contract with the Government.
7. The Requester is not entitled to any released Package that is subject to national defense security classification or the proprietary rights of others. The Requester shall report promptly the discovery of any such restricted material included with the Package to the US Air Force Software Release Authority below, and will follow all instructions concerning the use, safeguarding, or return of such material. The Requester shall not copy, or make further study or use of any such material later found to be subject to such restrictions.
8. I/we understand that the Package received is intended for domestic use (US and Canada) only. It will not be made available to other foreign owned or controlled corporations, or other foreign governments; nor will it be used in any contract with another foreign government.
9. The Requester and the Software Release Authority intend that all agreements under this Memorandum of Agreement shall be governed by the laws of the United States of America.
10. The undersigned Requester has the authority to bind the requesting organization to the terms of this Agreement.

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